Unit 2 Review

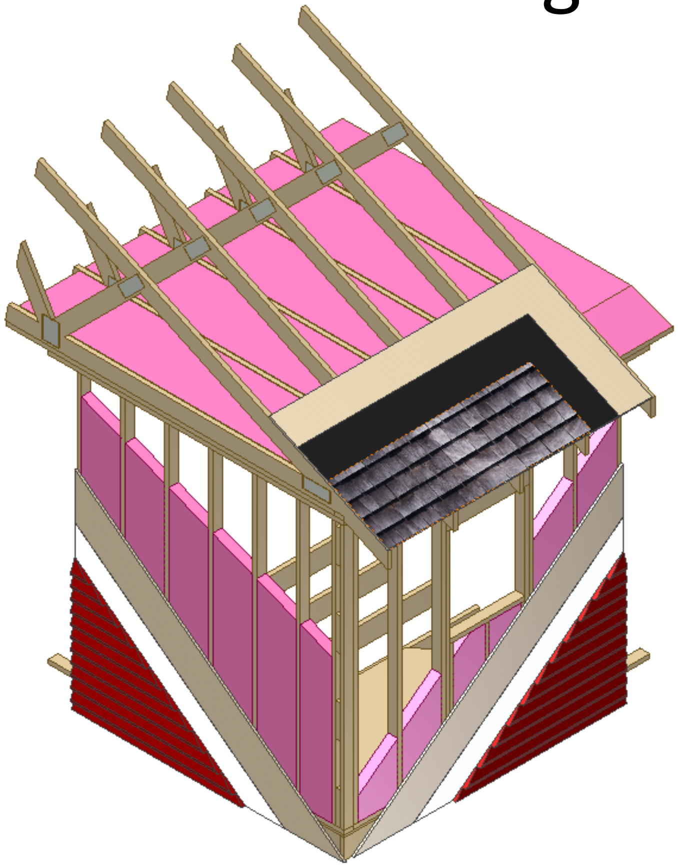
Building Design

Wood Framing Systems

- Residential structures are constructed with wood framing systems and are built using standard practices

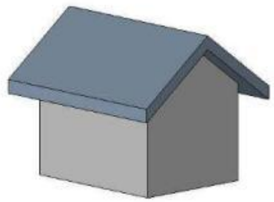
Be able to identify:

Floor joist	subfloor
Walls	top plate
Sole (sill) plate	roof truss
Insulation	sheathing
Vapor barrier	siding
Underlayment	shingles

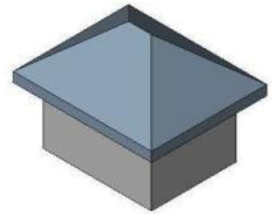


Roof Types: a variety of roof shapes and materials are available for residential structures to address aesthetic preferences, carry design loads and meet environmental challenges

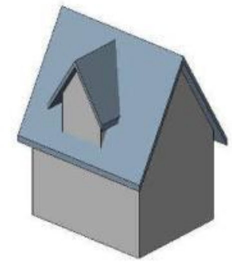
Shed



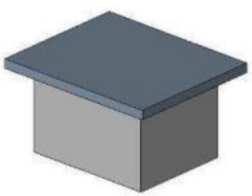
Gable



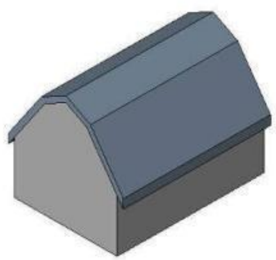
Hip



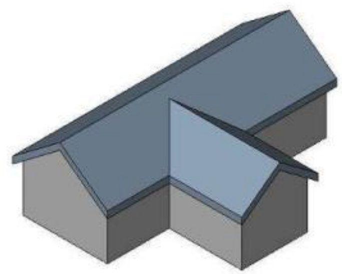
Gable with Dormer



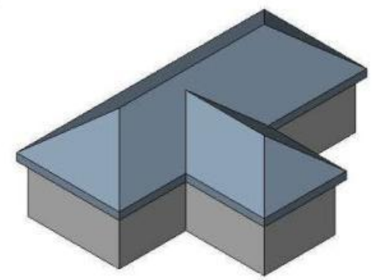
Flat



Gambrel



Gable & Valley



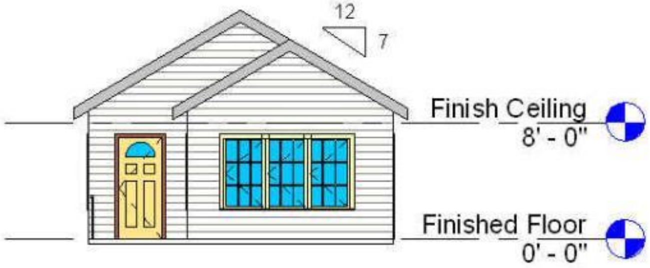
Hip & Valley

Roof Pitch

Roof pitch determined by rise/run

Run 12 in.

Rise 7 in.



Example:

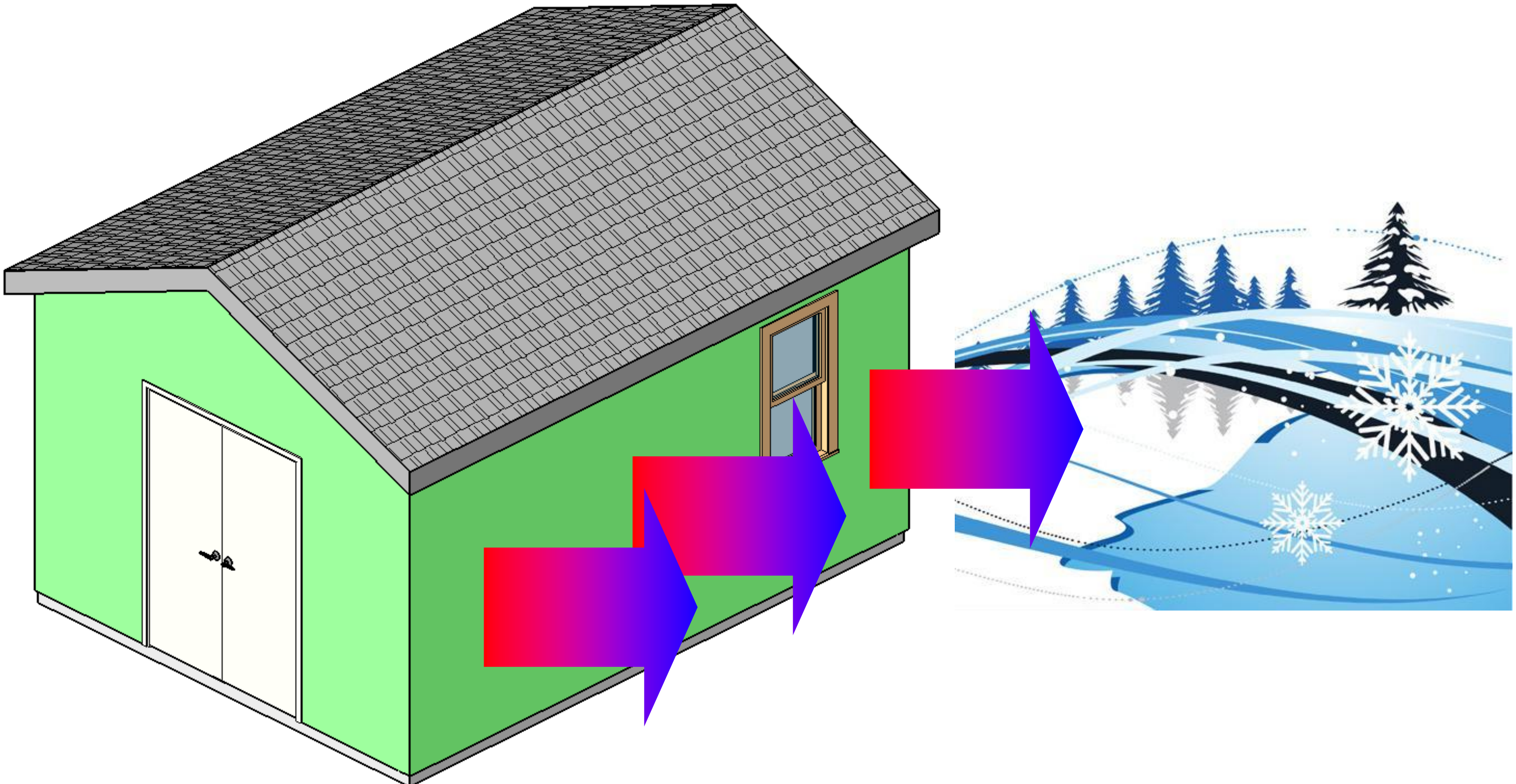
A 7/12 (pronounced “seven twelve”) pitch means that the roof rises 7 in. for every 12 in. horizontally.

Building Design

- Designers design, modify and plan structures using 3D architectural software
- Architects and engineers use a variety of drawings to document and detail a building project on construction drawings (site plan, floor plan, elevations, sections, schedules, etc)

Heat Transfer

Heat escapes through walls and openings when the temperature outside is lower than the temperature inside.



Formula for Heat Load

$$Q = AU\,\Delta T$$

Where **Q** = Total cooling/heating load in $\frac{\text{Btu}}{\text{hr}}$

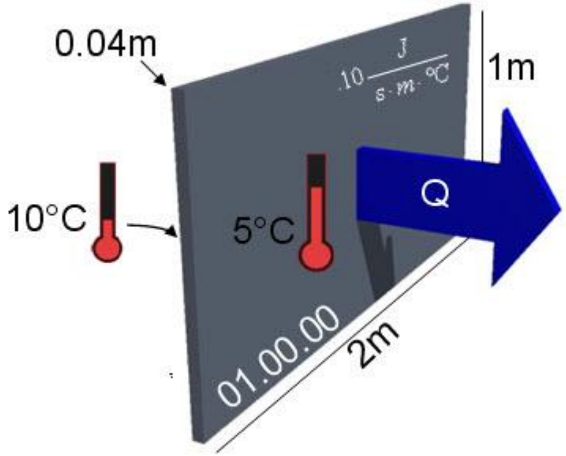
A = Area under investigation in ft^2

U = Coefficient of heat conductivity in $\frac{\text{Btu}}{\text{ft}^2 \cdot \text{hr} \cdot {}^\circ\text{F}}$

ΔT = Difference in temperature between outside and inside conditions in °F

Remember, R value = 1/U

Calculating Energy Transfe



Calculate the energy transfer in a wall section measuring 8ft by 10 ft by 0.25 ft thick with an R value = 4 ft^2 *ºF * hr/BTU if the opposing sides o the wall section have a temperature of 90°F and 75°F after one hour.

Area of thermal conductivity = A = 8 ft * 10 ft = 80 ft^2

U value = 1/ R value

U = 1/ R value = ¼
= 0.25 BTU /ft^2 *ºF * hr

Difference in temperature = ΔT = 90°F -75°F = 15°F

Q = U * A * change in Temp

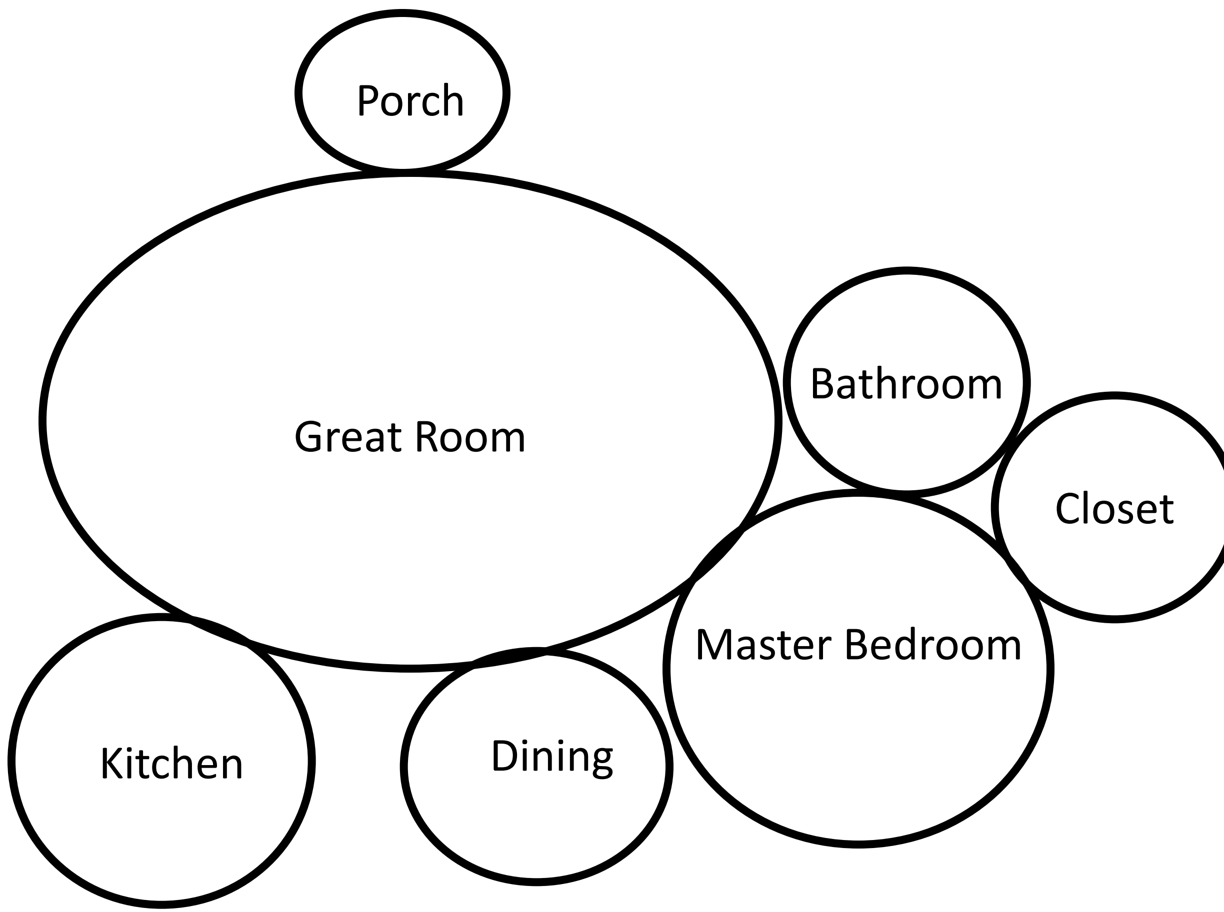
Q = 0.25 BTU /ft^2 *ºF * hr * 80 ft^2 * 15°F

Q = 300 BTU / hr

Residential Design

Bubble Diagrams

Freehand sketches used to determine locations and relationships



Purpose of Building Codes

- Protect health and safety of the public
- Dictate minimum requirements to be met
- Constrain location of structure, utilities, building construction, landscape components

Sustainable Design

Reduces the negative impact on the environment and human health, thus improving the performance during a building's life cycle. Careful consideration is given to water, energy, building materials, and solid waste.

Classification for LEED for Homes Credits

ID Innovation in Design

LL Location and Linkages: place home in socially and environmentally responsible ways in relation to larger community—already developed areas; near existing utilities

SS Sustainable Site: use of the property to minimize impact to the site- keep greenspace

WE Water Efficiency: water conservation indoors and outdoors- low flow toilets; collect and use rainwater

EA Energy and Atmosphere: onsite renewable energy resources- solar panels; geothermal

MR Materials and Resources: environmentally friendly materials- minimize waste; green materials

IEQ Indoor Environmental Quality: reduce exposure to pollutants- air circulation; filters

AE Awareness and Education

Residential ENERGY STAR

Tight Ducts
Improve indoor air quality and comfort with less noise

Tight Construction
Eliminates drafts, moisture, dust, pests, and pollen

Improved Insulation
Blankets the home to better control temperature and noise penetration.

Energy-Efficient Heating and Cooling Equipment
Reduces utility bills while increasing durability

High Performance Windows
Keep the heat in during the winter and out during the summer

Components of ENERGY STAR Qualified Homes

1. Efficient Insulation
2. High Performance Windows
3. Tight Construction and Ducts
4. Efficient Heating and Cooling
5. Efficient Products
6. Third Party Verification

Energy Conservation

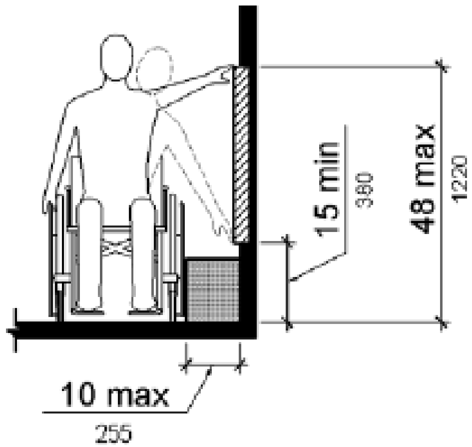
- Locate hot water heater in conditioned space
- Insulate hot water heater
- Insulate exposed hot water pipes
- Insulate cold water pipes with freezing potential
- Place water pipes in interior walls, if possible
- Use low-flow fixtures
- Seal all wall fenestrations

Principles of Universal Design (ADA)

- Equitable Use
  - The design is useful and marketable to individuals with diverse abilities (not just the disabled)
- Flexibility of Use
  - The design accommodates a wide range of individual preferences and abilities
- Simple and Intuitive Use
  - Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level

Universal Design (ADA) Home Features

- Room layout that allows wheelchair access and space to enter and close door
- Wide interior doorways (36 inches) and passages (42 inches)
- Switches and controls located at accessible heights (44 – 48 inches)
- Phone jacks and electrical outlets at accessible heights (min. 18 inches)
- Easy to use appliances:
  – front load washer and dryer
  – cook tops with front controls



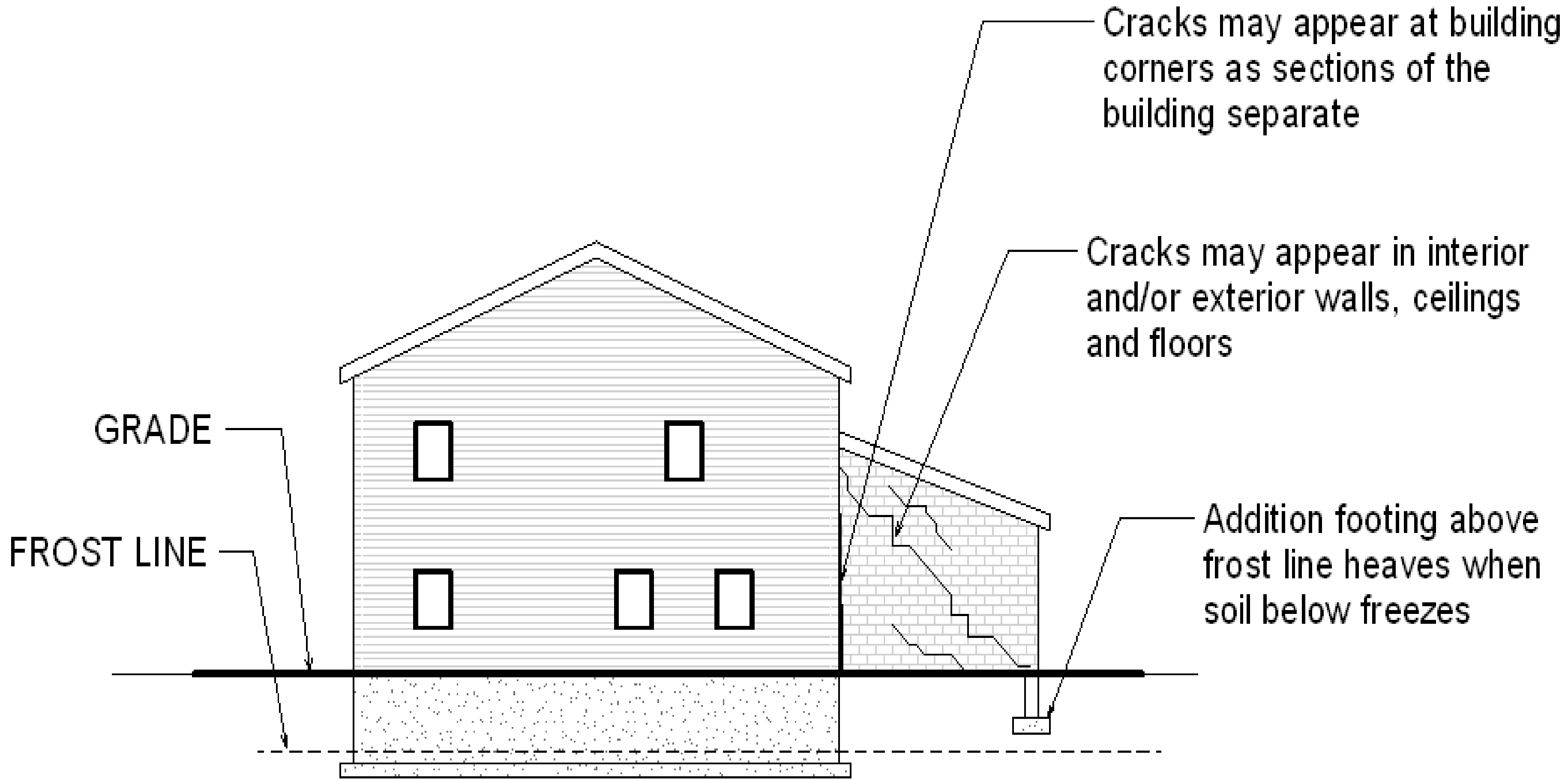
Universal Design Home Features

- Accessible entrance
  - No-steps entrance
  - Porch or overhang for protection from weather
  - Accessible path from street, sidewalk, and/or drive

Universal Design Home Features

- Wall reinforcing for grab bars in bathrooms – for future needs
- Adaptable cabinets
  - Provide open space beneath sinks
  - Provide open space below counter for workspace in kitchen
- Accessible bathroom layout

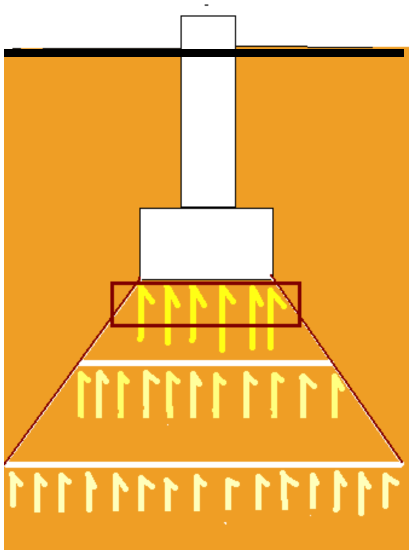
Foundations: Frost Heave



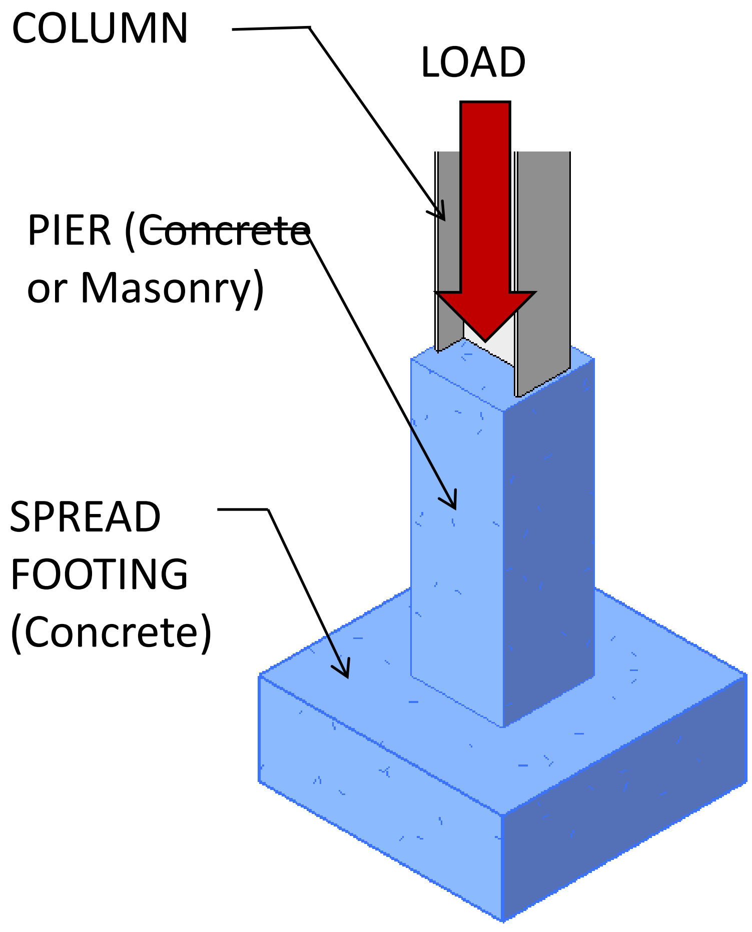
Shallow Foundations

Transfers loads to the soil very near the surface

- Spread footing or strip footing
- Slab-on-grade



Spread (Column) Footing



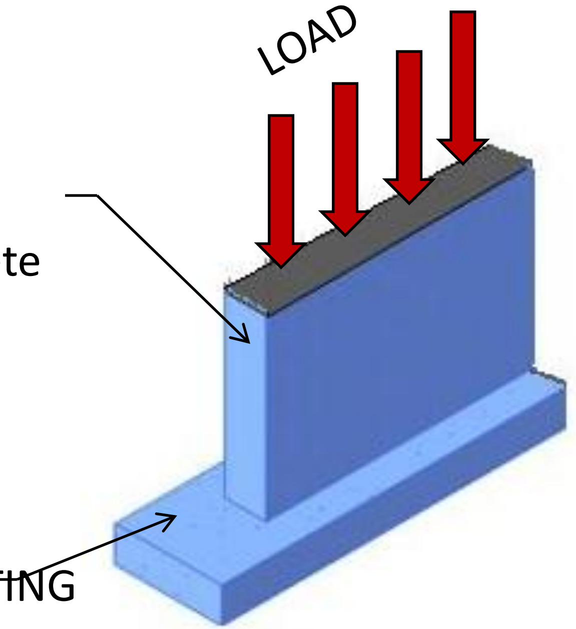
A footing that spreads the load over a broad area which supports one (or a few) load(s)

USES

Under piers or columns

Continuous (Strip) Foundation

A wide strip of reinforced concrete that supports loads from a bearing wall



USES

- Under foundation walls
- For crawl space/basement

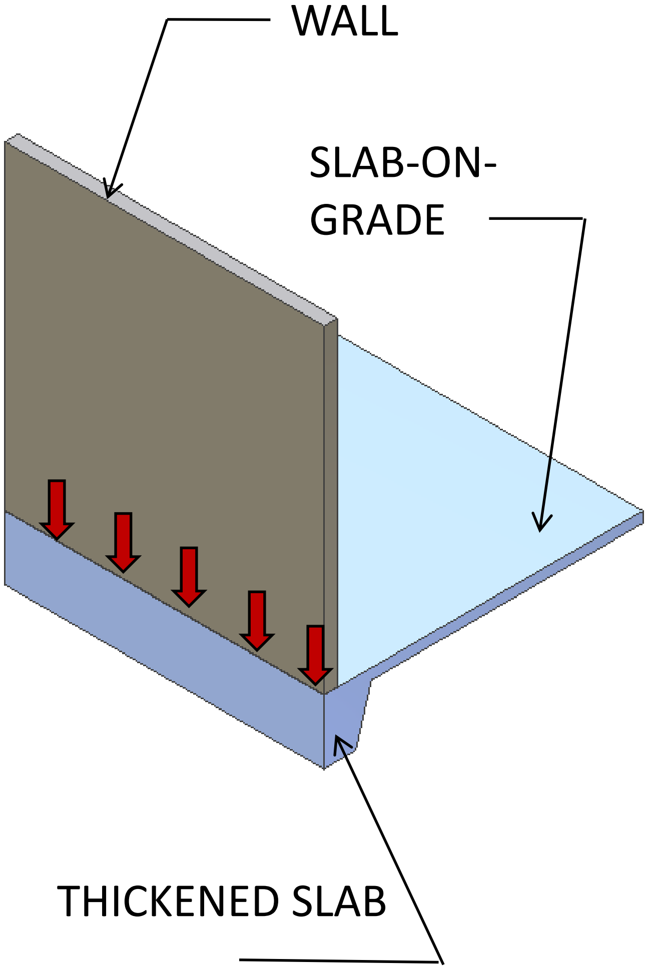
Slab-on-Grade and Thickened Slab

Slab-on-Grade – Reinforced concrete floor supported by soil

Thickened Slab – A slab on grade with an integral footing created by thickening the slab

USES

Shallow frost depth or when frost protection is used (instead of strip footing)



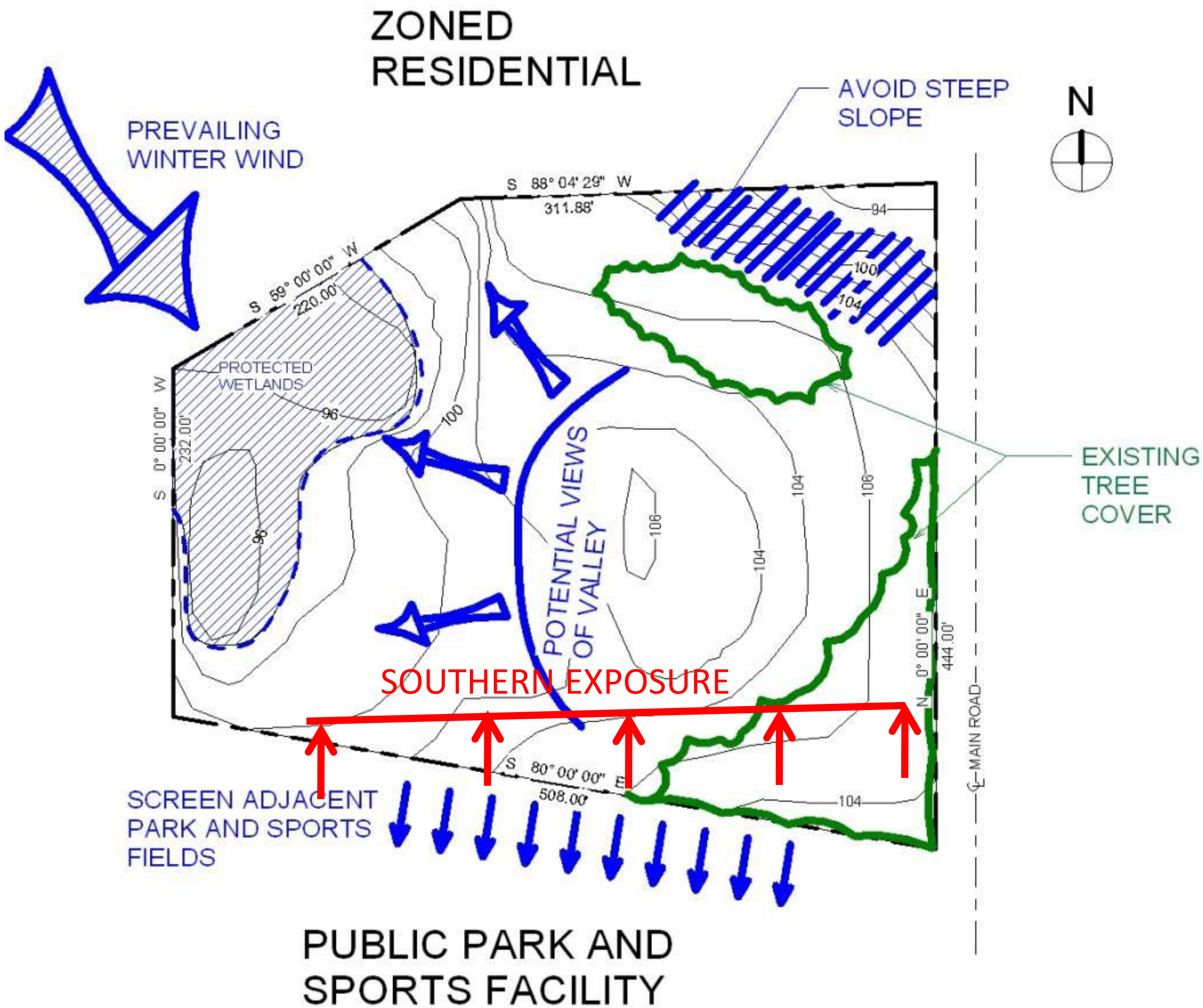
Site Plan Requirements

- Initial Details: scale, legal description, property line, setbacks
- Existing Conditions: topography, roads, utilities
- Proposed Construction: structure, roads, utilities
- Drainage: finished grade, drainage structures

Site Plan Considerations

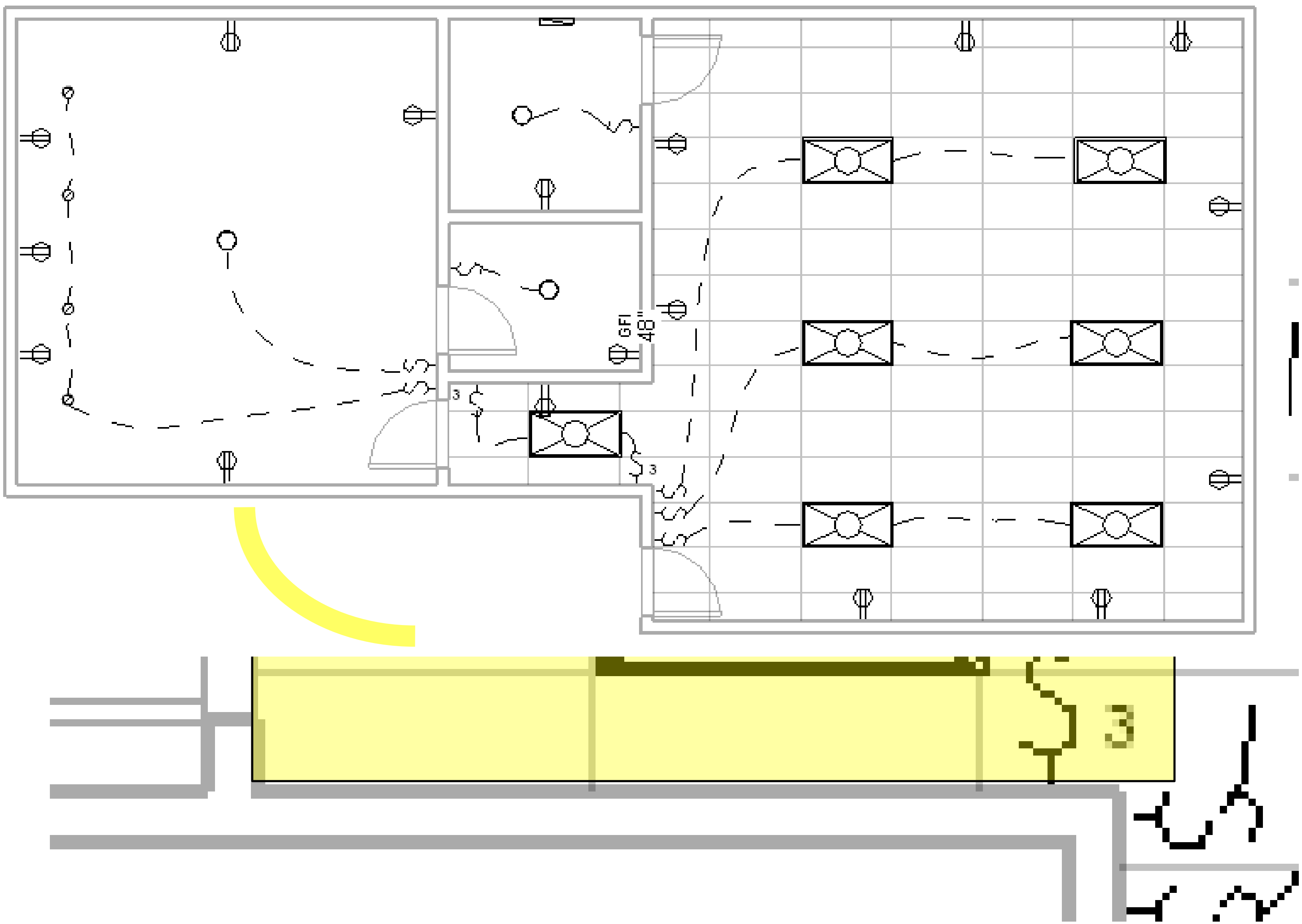
- Solar Orientation
- Wind Orientation
- Sound Orientation
- View Orientation
- Terrain Orientation
- Existing Features
- Site Opportunities Map
- Landscaping
- Location of Utilities
- Building Lines
- Ingress and Egress

Site Opportunities Map



Utilities

Electrical Plans



Plumbing System

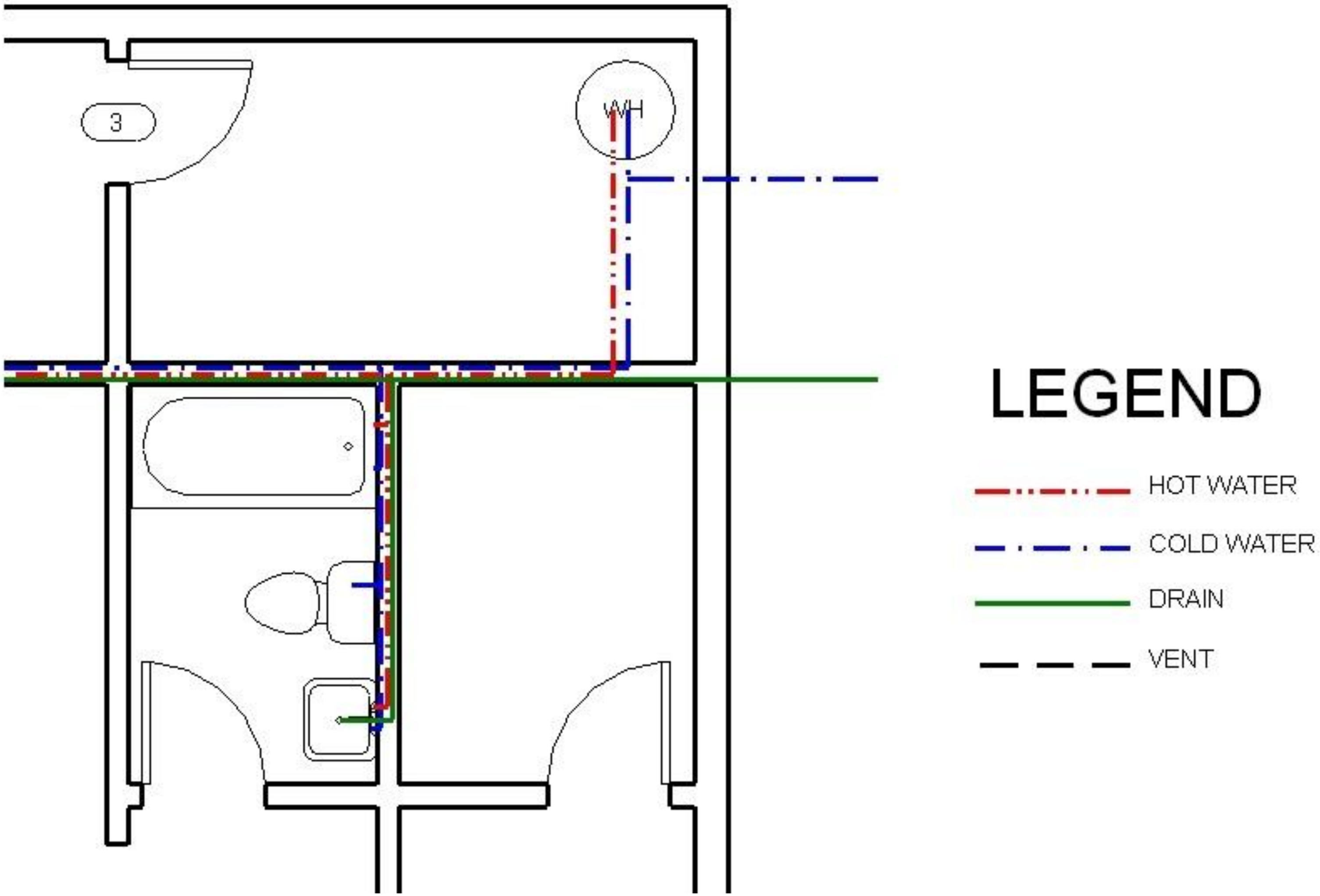
- Water supply pipes
- Fixture – A device that uses water (sink, toilet, dishwasher, etc.)
- Soil, waste, and vent pipes
- Drain and sewer
- Gas pipes
- Storm water drainage

Plumbing Codes

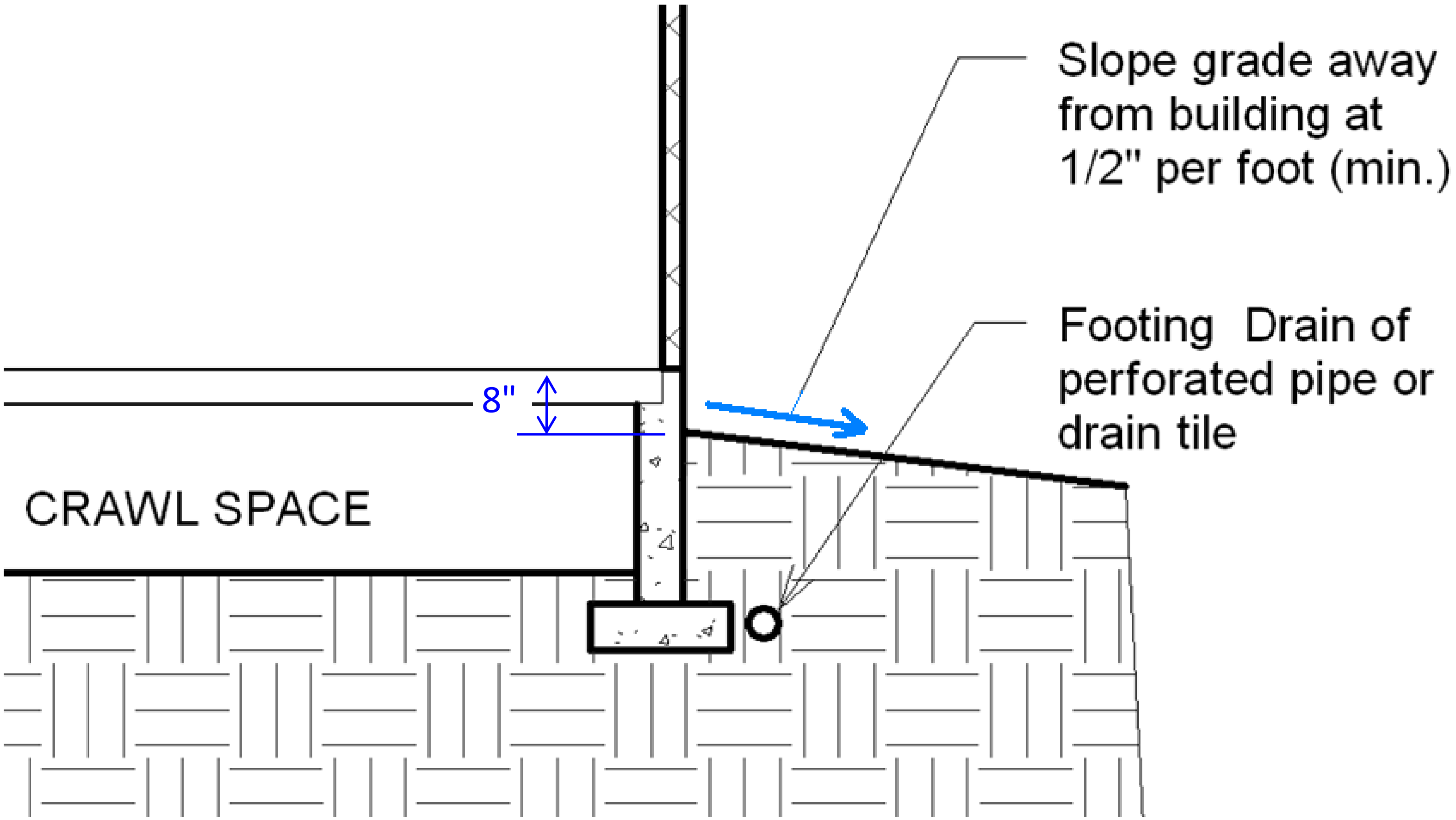
©iStockphoto.com

- Supply pipe size dependent upon
  - Amount of water
  - Water pressure
  - Pipe length
  - Number of stories
  - Flow pressure necessary at farthest point in system
- Drainage and vent pipe size dependent upon
  - Plumbing Fixture Units
    - Type of fixture
    - Estimated amount of waste

Plumbing Plan

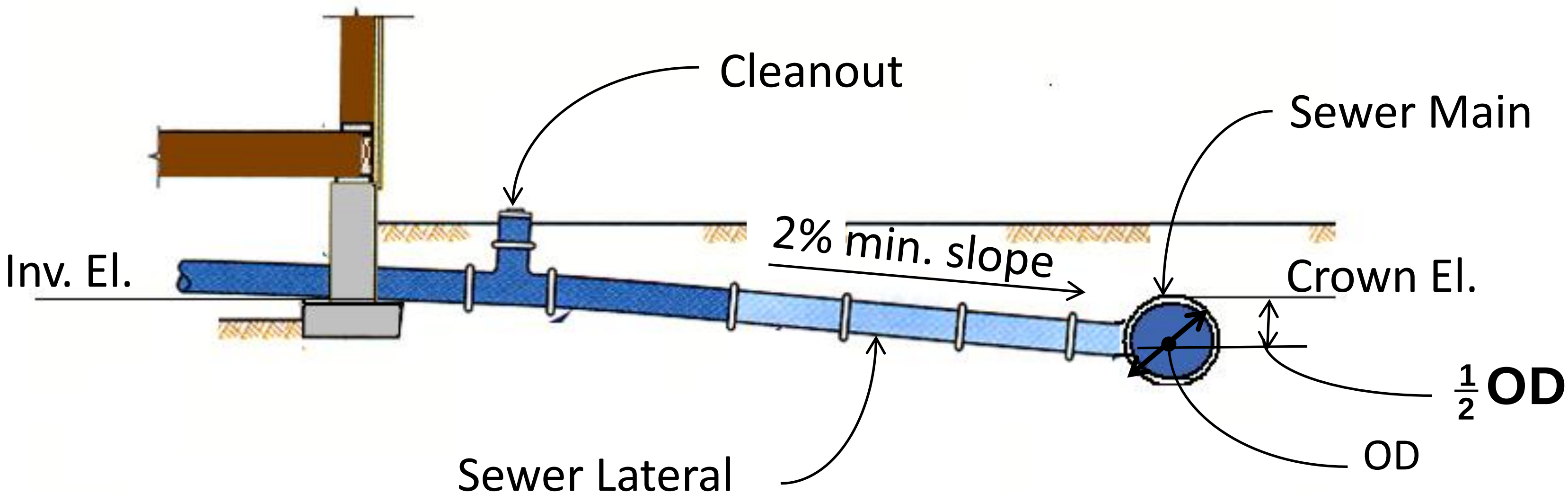


Drainage



Slope grade away from building at 1/2" per foot (min.)
Footing Drain of perforated pipe or drain tile
8"
CRAWL SPACE

Sewer Lateral Slope



$$\text{Sewer Lateral Slope} = \frac{\text{Invert of Lateral at building} - \text{Crown Elev. of Main} + \frac{1}{2}\text{OD}}{\text{Distance from building to Sewer Main}} \times 100\%$$

where $\frac{1}{2}$OD = half the outside diameter of the sewer branch or main

Where Does Storm Water Go?

- Absorbed by the ground/vegetation
- Runoff
  - Waterway
  - Street
  - Neighbor
- Detained on site
  - Detention/retention pond
  - Underground storage

The Rational Method

The Rational Formula (with recurrence adjustment)

$$Q = C_f\, C\, i\, A$$

Q = Peak runoff rate (cubic ft/sec)

C_f = Runoff coefficient adjustment factor (from table)

C = Runoff coefficient (dependent on type of surface) (calculate from tables)

i = Rainfall intensity (in./hour) (from a map or a table)

A = Area in **acres**

I: Storm Intensity

- Storm intensity for a given design storm can be found from maps, tables, or charts.

NOAA Tech. Paper No. 40

Example

Suppose a developer purchased a 3-acre property in Nashville, Tennessee. Three fourths of the property is farm and one-fourth is lawn with 2% slope. A light industrial site is planned for the property. A 25 year, 1 hour rainfall is the design storm.

Find the change in peak runoff (i.e., find the difference in the pre-development peak runoff and post-development peak runoff).

Pre-Development Analysis

Using the Rational Formula (with recurrence adjustment)

$$Q = C_f C\ i\ A$$

A = Area of the property in acres

A = 3 acres

Pre-Development Analysis

C_f = Runoff Coefficient adjustment factor
= 1.0 for a 10 year storm.

Return Period	C_f
1, 2, 5, 10	1.0
25	1.1
50	1.2
100	1.25

Pre-Development Analysis

C = Runoff Coefficient. Need to find a composite C

Pre-development: ¾ Farmland and ¼ lawn with 2% slope

From Rational Method Runoff Coefficients table

C farm = 0.05 – 0.3 . Use an average. C farm = (0.05 + .3)/2 = 0.13

C lawn = 0.18 – 0.22 . Use an average. C farm = (0.18 + .22)/2 = 0.2

Composite C: (C1 * A1 + C2 * A2)/A total

Composite C = (0.13 * ¾ of 3 acres + 0.2 * ¼ of 3 acres) / 3 acres

Composite C = (0.29 + 0.15)/3 = 0.15

Pre-Development Analysis

i = Rainfall intensity

Use the Weather Bureau Intensity chart for Nashville, TN or get intensity from a map.

25 year
1 hour
storm

Precipitation Intensity Estimates (in/hr)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	4.57	3.65	3.04	2.08	1.30	0.77	0.56	0.33	0.20	0.12	0.07	0.04	0.03	0.02	0.01	0.01	0.01	0.01
2	5.35	4.28	3.59	2.48	1.55	0.91	0.66	0.40	0.23	0.14	0.08	0.05	0.03	0.03	0.02	0.01	0.01	0.01
5	6.17	4.94	4.16	2.96	1.90	1.11	0.80	0.48	0.28	0.17	0.10	0.06	0.04	0.03	0.02	0.02	0.01	0.01
10	6.82	5.45	4.60	3.33	2.17	1.27	0.92	0.55	0.33	0.20	0.12	0.06	0.05	0.04	0.02	0.02	0.01	0.01
25	7.63	6.08	5.14	3.81	2.54	1.48	1.08	0.65	0.38	0.23	0.14	0.08	0.05	0.04	0.03	0.02	0.02	0.01
50	8.24	6.56	5.54	4.17	2.83	1.66	1.20	0.73	0.43	0.26	0.16	0.08	0.06	0.05	0.03	0.02	0.02	0.02
100	8.83	7.02	5.92	4.53	3.12	1.83	1.33	0.82	0.48	0.29	0.18	0.09	0.07	0.05	0.03	0.02	0.02	0.02
200	9.41	7.46	6.27	4.88	3.42	2.01	1.47	0.90	0.53	0.32	0.19	0.10	0.07	0.06	0.03	0.03	0.02	0.02
500	10.12	8.00	6.71	5.34	3.83	2.26	1.66	1.03	0.60	0.36	0.22	0.12	0.08	0.06	0.04	0.03	0.02	0.02
1000	10.66	8.39	7.02	5.69	4.15	2.45	1.80	1.12	0.66	0.39	0.24	0.13	0.09	0.07	0.04	0.03	0.02	0.02

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting forces estimates near zero to appear as zero.

i = 2.54 in./hr

Pre-Development Analysis

Q pre = Cf * C * I *A

Q pre = 1.1 * 0.15 * 2.54 * 3

Q pre = 1.26 cfs

Post-Development Analysis

C = light industrial = 0.5-0.8. Use average of 0.65.

Rainfall intensity same. Area same

Q post = Cf * C * I *A

Q post = 1.1 * 0.65 * 2.54 * 3

Q pre = 5.45 cfs

Change in peak runoff = 5.45 cfs – 1.26 cfs = 4.19 cfs

Water Systems: appropriate flow rate, pressure and water quality are needed for effective water supply and use

Static Head

- Potential energy of the water at rest
- Measured in feet of water
- Change in elevation between source and discharge
- Ex: What is the static head at a residential supply line if the water level in the elevated tank is 943 ft and the elevation at the supply line is 890 ft?

EPA at http://www.epa.gov/region02/superfund/npl/mohonkroad/images.html

943 ft – 890 ft = 53 feet of water

Definition

Static Pressure

- Pressure of water at rest
- Measured in pounds per square inch (psi)
- 2.31 feet of water = 1 psi
- Ex: What is the static pressure at distribution if the static head is 53 ft of water?

$$\mathbf{53\ ft} \cdot \frac{\mathbf{1\ psi}}{\mathbf{2.31\ ft}} = \mathbf{22.9 psi}$$

- Is this the pressure at which water would exit a faucet in the house?

Definitions

Head Loss

- Energy loss due to friction as water moves through the distribution system
  - Pipes
  - Fittings
    - Elbows, tees, reducers, etc.
  - Equipment (pumps, etc.)
- Major losses = head loss associated with friction per length of pipe
- Minor losses = head loss associated with bends, fittings, valves, etc.

Calculating Head Loss

Hazen-Williams formula

$$h_f = \frac{10.44 \cdot L \cdot Q^{1.85}}{C^{1.85} \cdot d^{4.8655}}$$

Where: h_f = head loss due to friction (ft)

L = length of pipe (ft)

Q = flow rate of water (gpm)

C = Hazen-Williams constant

d = diameter of the pipe (in.)

Hazen-Williams Constant, C

Pipe Material	Typical Range	Clean, New Pipe	Typical Design Value
Cast Iron and Wrought Iron	80 - 150	130	100
Copper, Glass or Brass	120 - 150	140	130
Cement lined Steel or Iron		150	140
Plastic PVC or ABS	120 - 150	140	130
Steel, welded and seamless or interior riveted	80-150	140	100

Equivalent Length in feet of pipe (Generic)

Flanged Fittings		Pipe Size								
		1/2	3/4	6	8	10	12	14	16	18
Elbows	Regular 90 degree	0.9	1.2	8.9	12.0	14.0	17.0	18.0	21.0	23.0
	Long radius 90 degree	1.1	1.3	5.7	7.0	8.0	9.0	9.4	10.0	11.0
	Regular 45 degree	0.5	0.6	5.6	7.7	9.0	11.0	13.0	15.0	16.0
Tees	Line Flow	0.7	0.8	3.8	4.7	5.2	6.0	6.4	7.2	7.6
	Branch Flow	2.0	2.6	18.0	24.0	30.0	34.0	37.0	43.0	47.0
Return Bends	Regular 180 degree	0.9	1.2	8.9	12.0	14.0	17.0	18.0	21.0	23.0
	Long radius 180 degree	1.1	1.3	5.7	7.0	8.0	9.0	9.4	10.0	11.0
Valves	Globe	38.0	40.0	190.0	260.0	310.0	390.0			
	Gate			3.2	3.2	3.2	3.2	3.2	3.2	3.2
	Angle	15.0	15.0	63.0	90.0	120.0	140.0	160.0	190.0	210.0
	Swing Check	3.8	5.3	63.0	90.0	120.0	140.0			

Water Pressure Calculations

A home has a water supply connection at the street with an elevation 2675 feet and a pressure of 68 psi. The elevation of the shower head in the home is 2712 feet. Between the street connection and the shower head, there are 158.94 feet of 3 inch copper pipe with six 45 degree elbows, and 57.3 feet of ¾” copper pipe with two 45 degree elbows. Discharge through the shower is 10 gpm. Use a Hazen-Williams constant for copper pipe of 130.

Equivalent lengths:

one 3” – 45 degree elbow: 5.27 feet

one ¾” - 45 degree elbow: 1.85 feet.

Is there enough pressure (above 40 gpm) to take a nice shower?

Water Pressure

Step 1: Find the head loss in the ¾ in. and the 3 in. pipes.

Hazen-Williams Formula

$$h_f = \frac{10.44 \cdot L \cdot Q^{1.85}}{C^{1.85} \cdot d^{4.8655}}$$

L ¾" pipe = length of pipe plus elbows

= 57.3 feet + 2 * 1.85 = 61 feet

Hf = 10.44 * 61 feet * (10 gpm $)^{1.85}$ / [130 $^{1.85}$ * .75 in $^{4.8655}$]

Hf = 22.4 feet from ¾ inch pipe

Water Pressure

Step 1: Find the head loss in the ¾ in. and the 3 in. pipes.

Hazen-Williams Formula

$$h_f = \frac{10.44 \cdot L \cdot Q^{1.85}}{C^{1.85} \cdot d^{4.8655}}$$

L 3” pipe = length of pipe plus elbows

= 158.94 feet + 6 * 5.27 = 190.56 feet

Hf = 10.44 *190.56 feet * (10 gpm)$^{1.85}$ / [130 $^{1.85}$ * 3 in $^{4.8655}$]

Hf = .08 feet from 3 inch pipe

Total head loss = 22.4 feet + 0.08 feet = 22.48 feet

Water Pressure

Step 2: Find the static head at the shower due to elevation

Head at street: 68 psi = 68 psi * 2.31 feet per psi

= 157.08 feet of head

Subtract out elevation change from street to shower: 2712 feet – 2675 feet = 37 feet change

SH = 157.08 feet – 37 feet elevation change

SH = 120.08 feet at shower

Water Pressure

Step 3: Find the dynamic pressure at the shower

DH = SH – losses

DH = 120.08 feet – 22.48 feet

DH = 97.6 feet

Dynamic pressure = 97.6 feet/2.31 feet/psi

= 42.3 psi

- There should be enough pressure for a nice shower.